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Effects of Crew-Aiding Behaviors on Soldier Performance During Target Engagement Tasks in a Virtual Battlefield Simulation

by Chuck H. Perala, Bruce S. Sterling, Steve Scheiner, and Deborah Butler

ARL-TR-4026 **February 2007**

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REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED (From - To)**
February 2007	Final	June through July 2006

4. TITLE AND SUBTITLE

Effects of Crew-Aiding Behaviors on Soldier Performance During Target Engagement Tasks in a Virtual Battlefield Simulation

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Chuck H. Perala and Bruce S. Sterling (both of ARL); Steve Scheiner (DCS Corp); Deborah Butler (AMRDEC)

5d. PROJECT NUMBER

7MB25R

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Research Laboratory
Human Research & Engineering Directorate
Aberdeen Proving Ground, MD 21005-5425

8. PERFORMING ORGANIZATION REPORT NUMBER

ARL-TR-4026

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBERS

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This research examined the impact of crew-aiding behaviors (CABs) on Soldier workload, stress, situation awareness, and performance in a laboratory setting. Specifically, this experiment examined the effectiveness of CABs designed to prioritize targets (based on threat level and proximity) and provide weapons platform and munition recommendations to service each target. This condition was compared with a NoCAB or manual condition in which participants performed the same task of prioritizing and engaging targets without the use of the CABs.

Results showed that CABs significantly reduced time and workload when participants conducted the task of prioritizing and engaging targets. Participants took significantly less time to complete the prioritization and engagement task when using CABs versus when they performed the same task manually (i.e., the NoCAB condition). Overall task time was reduced by 36% when CABs were used. Overall workload, as well as the subscales of mental, temporal, and effort workload, were significantly reduced when CABs were used. Overall workload was 28% less when CABs were used versus when they were not. Mental and temporal workload were both 46% less when CABs were used versus when they were not, and effort workload was 36% less when were used versus when they were not.

15. SUBJECT TERMS

CAB; crew-aiding behavior; decision aids; target prioritization

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Chuck H. Perala
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR	50	**19b. TELEPHONE NUMBER** (*Include area code*) 502-624-8778

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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Acknowledgments

This study was a joint effort among the U.S. Army Research Laboratory; the U.S. Army Tank-Automotive Command Research, Development, and Engineering Center; the U.S. Army Aviation and Missile Research, Development, & Engineering Center; the Unit of Action Maneuver Battle Laboratory (UAMBL); DCS Corporation; and Alion Science and Technology. The authors would like to thank the many representatives from these organizations whose dedication and hard work made Research, Development, and Engineering Command (RDECOM)-UAMBL (RUX06) a success.

1. Introduction

As the U.S. Army network-centric digital battlefields continue to expand, so do the workload demands placed on Soldiers who use the increasing amount of information to conduct their missions. In an effort to reduce workload and stress for these Soldiers, decision aids, called crew-aiding behaviors (CABs), have been developed, which provide a level of automation designed to assist Soldiers in the performance of their tasks. A field-based experiment was conducted to assess the effects of these decision aids on Soldier performance in a simulated battlefield environment. We evaluated the effects of the CABs by measuring and comparing levels of task time, workload, stress, and situation awareness between two experimental conditions. The experimental task was target prioritization, weapon system and munition matching, and target engagement with and without the use of the decision aids. This report describes the details associated with the experiment, statistical methods used, analytical results, and an interpretation and discussion of those results.

1.1 Background

Soldiers on future battlefields will have a greater number of simultaneous tasks to perform while conducting their missions. They must maintain local security to guard against threats from enemy vehicles or dismounted threats with hand-held weapons. They must be able to receive instructions from platoon level or above and provide relevant information to their leaders and subordinates. Soldiers are also responsible for the mobility of their platform and plotting routes for unmanned aerial and ground platforms under their control. They must also monitor sensor information from these unmanned systems, interpret the information, and provide relevant portions to their chain of command. In addition to this, they must seek, close with, and destroy enemy forces of disparate types and strengths. Decision aids, also known as CABs, may prove useful in assisting Soldiers in the performance of these tasks. CABs may consist of software designed to autonomously drive vehicles, plot routes for road marches, plot tactical routes to observation points (OPs), establish effective support-by-fire missions, or prioritize targets for engagement. These CABs should reduce workload and stress for Soldiers, as well as improve other measures of performance (such as reduce target acquisition and engagement time).

This experiment, known as the Lethality Experiment, was one of several experiments conducted under the name of RDECOM-UAMBL (RUX06). These experiments were conducted jointly between the U.S. Army Research Development and Engineering Command (RDECOM), specifically, the U.S. Army Research Laboratory's (ARL's) Human Research and Engineering Directorate; Tank Automotive Research Development and Engineering Center (TARDEC); Aviation and Missile Research Development and Engineering Center (AMRDEC); and the Unit of Action Maneuver Battle Lab (UAMBL) in support of the Crew-integration and Automation

Test bed (CAT) Advanced Technology Demonstration (ATD) program, or CAT-ATD. Experimentation was conducted at Fort Knox, Kentucky, in July 2006.

1.2 Research Objective

The objective of this research was to determine the impact of CABs on Soldier workload, stress, situation awareness, and performance. Specifically, this experiment examined the effectiveness of CABs designed to prioritize targets (based on threat level and proximity) and provide weapons platform and munition recommendations to service each target.

2. Method

2.1 Apparatus

This experiment took place entirely in simulation; however, the crew station was identical to that used in the actual field vehicle. The Soldier-in-the-loop (SIL) interface (see figure 1) consisted of three vertically oriented liquid crystal displays situated in an arc in front of a seated participant. Each display was divided in two, horizontally, with information on each of the six "screens" provided from various computer systems, which were transparent to the SIL operation and the participant. Figure 2 shows the basic layout of the three displays (six screens) used during this experiment, with the target prioritization list on the center display. Participants could select targets and weapons by touching on-screen buttons or by scrolling through the list using a thumb button on the driver's yoke. The yoke was also used to slew the weapon system and to engage each target. Detailed information regarding each screen and button functions is available in appendix A.

Figure 1. CAT SIL crew station simulator.

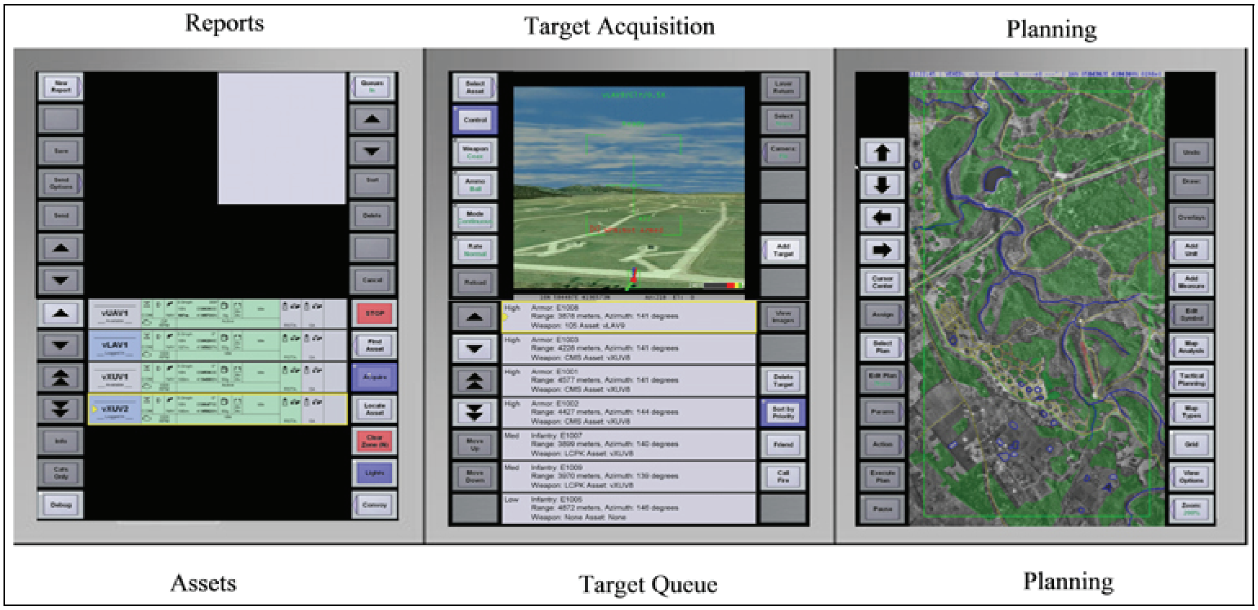

Figure 2. CAT SIL displays.

2.2 Performance Measures

2.2.1 Workload

To measure subjective self-ratings of perceived workload, the National Aeronautics and Space Administration (NASA)-Task Load Index (TLX) was used. The NASA-TLX (Hart & Staveland, 1988) is a multi-dimensional rating procedure that derives an overall workload score based on ratings from six subscales. The subscales include Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and Frustration. Ratings were collected via questionnaire. This instrument is included in appendix B.

2.2.2 Stress

One-item rating scales measuring physical stress and mental stress were used. These scales are shown in appendix B.

2.2.3 Situation Awareness

The measure of situation awareness (SA) used was a variation of the China Lake Situation Awareness (CLSA) rating scale developed by Adams (1998). The original CSLA is a five-point scale developed by the Naval Air Warfare Center to measure SA in flight. The version used here is a 10-point scale adapted to measure SA more generally. This measure is shown in appendix B.

2.2.4 Task Time

The measure of task time consisted of the total time required to complete the task of prioritizing and servicing targets. These measures were recorded manually by the experimenter during trial runs.

2.3 Participants

Twelve active-duty male Soldiers volunteered for this experiment. One Soldier was a Captain (O3), seven Soldiers were Sergeants First Class (E7), and four Soldiers were Staff Sergeants (E6). Military occupational specialties were primarily M1 Armor Crewmen (19K). Nine participants were 19K, one 19D (Cavalry Scout), one 14E (Patriot Fire Control Enhanced Operator), and one 25B (Information Systems Operator-Analyst).

2.4 Training

Participants were given a 1-hour block of instruction and practice for the task of prioritizing and servicing a list of targets, in both CAB and NoCAB conditions. The instruction consisted of familiarization with the displays and controls and a detailed explanation of the tasks, conditions, and standards expected during experimentation. Depending on which condition was presented first, training for that condition was presented before experimentation. For example, if a participant was testing in the CAB condition first, the CAB training was conducted before testing in the CAB condition. Following testing and a short break, the NoCAB training was conducted before the NoCAB test.

2.5 Procedures

2.5.1 Overview

Participants were randomly assigned a participant identification number and then given an overview of the experiment and familiarization with the surveys. Baseline measures of workload, stress, and SA were taken before each trial. For stress, participants were asked to rate how they felt "right now". For baseline workload and SA, participants were asked to rate the level of workload and SA they experienced while driving to work that morning.

Participants were then trained and tested in target prioritization, weapons and munitions selection, and target engagement procedures; again, one condition was taught and tested first and then the other. Half of the participants engaged targets first using CABs, and half engaged targets first without using CABs. Each participant tested in both CAB and NoCAB conditions. After each experimental trial, participants completed the workload, stress, and SA surveys.

In both trials, the participant was notionally task organized with an Armed Robotic Vehicle-Assault (ARV-A) and Armed Robotic Vehicle-Reconnaissance (ARV-R). The participant's Mounted Combat System (MCS) platoon was providing fire support for a Reconnaissance and

Surveillance (R&S) Vehicle Company. The participant's platoon leader detected a potential threat at approxi-mately 2.5 kilometers from the participant's vehicle, which required additional R&S. The platoon leader instructed the participant to use the ARV-R to investigate. The participant's mission began after the ARV-R reconnaissance was complete. The participant's task was to analyze and prioritize all targets that were presented in the target queue, select the appropriate weapons platform and munition type, and engage and defeat as many of those threats as possible, as quickly as possible. All targets were presented simultaneously.

2.5.2 Stepwise Procedures

Participants were seated at the SIL station (see figure 1) and given a 1-hour block of instruction regarding each facet of the interface, controls, functions, and required task, conditions, and standards. After this block of instruction, participants took a short break and then were asked to practice using the SIL in a manner consistent with the experimental tasks. This practice session was for the particular trial with which the participant started. For example, if he started with Trial 1 first, this practice session was in the NoCAB mode. Conversely, if he started with Trial 2 first, this practice session was in the CAB mode. Odd-numbered participants were administered Trial 1 first and even-numbered participants were administered Trial 2 first. Once the instructor and participant were satisfied with the participant's level of understanding, comfort, and proficiency with the system, the experimental trial was administered. During each trial run, the experimenter timed each target prioritization and engagement sequence from start to finish. After each trial, participants were asked to complete the workload, stress, and SA surveys. Following a short break, participants were allowed to practice before the second and final trial.

2.5.2.1 Trial 1

This trial entailed prioritizing a list of targets and matching weapons to threats without the use of CABs. The participant was presented with a list of targets in the target queue. This list was not sorted or prioritized in any way, and no weapon or munition recommendations were given. The task was to prioritize the list based on proximity and threat and to select the appropriate weapon system and munition for engagement. The next step was to engage and destroy the target. After destroying the target, the participant deleted that target from the target queue and moved to the next target. The trial ended when all targets were destroyed or all munitions from each weapons platform were expended. Surveys were completed at the end of the trial.

2.5.2.2 Trial 2

This trial entailed servicing a list of targets that were sorted and prioritized automatically by the CABs. The task was to verify and select each target in the target queue, verify the recommended weapon and munition, engage and destroy the target, delete the target from the target queue after verifying its destruction, and then move to the next target in the target queue. The trial ended when all targets were destroyed or all munitions from each weapons platform were expended. Surveys were completed at the end of the trial.

2.6 Analysis

All dependent measures (workload, stress, and SA) were analyzed with the use of a mixed model analysis of variance (ANOVA) with one between-subject factor (order of conditions) with two levels (CAB first and NoCAB first) and one within-subject factor (condition) with three levels (baseline, CAB, and NoCAB). Performance measures were analyzed with a mixed model ANOVA with one between-subject factor (order of conditions) with two levels (CAB first and NoCAB first) and one within-subject factor (condition) with two levels (CAB and NoCAB).

3. Results

A multivariate ANOVA (MANOVA) was conducted separately on each of the data sets collected from the experiment. This was done since the data collected were repeated measures. Since sphericity assumptions are not made in the MANOVA, this test is considered to be “exact” for repeated measures designs, while the univariate approach can only be considered “approximate” (Vasey & Thayer, 1987).

Based upon the MANOVA results, individual ANOVAs were conducted on each data set. *Only those significant main effects and interactions found in the ANOVAs that were also significant in the MANOVA were reported*. This was done because individual ANOVAs do not provide adequate protection against making Type I errors (i.e., when a true null hypothesis is rejected), when multiple dependent variables are analyzed separately. Performing the MANOVA first ensures that if significant differences are found between population means, the researcher may be confident that real differences actually exist and ANOVAs can then be used to determine where the differences actually occur (Johnson, 1998).

To determine the loci of significance in factors with more than two levels, a *post hoc* analysis using the Tukey-Kramer Least Squares Difference test was performed for each data set, as appropriate. This test was chosen because of its ability to better control error rate and generate 95% confidence intervals better than other *post hoc* tests, such as Newman-Keuls.

3.1 Overall Workload

The overall measure of workload was assessed across conditions (baseline, CAB, and NoCAB). This workload measure was an aggregate of the workload subscales. Additionally, the individual subscales, including mental, physical, temporal, performance, effort, and frustration, were analyzed independently across conditions. Presentation order was a between-subject factor and was analyzed to determine whether the order of condition (i.e., CAB first or NoCAB first) significantly affected workload results.

For the dependent variable Overall Workload, the three levels in the overall model were Baseline Workload, CAB Workload, and NoCAB Workload. Means for this data set are shown in table 1. Significance (at $p \leq 0.05$) was observed for Workload in the overall MANOVA model using the Wilk's lambda (λ) test (see table 2). No significant effect was observed in the MANOVA for Order or Order by Condition.

ANOVA results also showed a significant effect for Overall Workload ($F_{2,22} = 6.016$, $p = 0.005$). The ANOVA summary table for Overall Workload is provided in table 3. *Post hoc* results are shown in table 4. As these results indicate, significant difference was observed between Baseline and NoCAB and between CAB and NoCAB. For the Baseline and NoCAB comparison, results indicate that overall workload was significantly higher in the NoCAB condition (42.75) than in the Baseline condition (30.83). Also, results indicate that overall workload was significantly higher in the NoCAB condition (42.75) than in the CAB condition (33.33). There was no significant difference between the Baseline and CAB conditions. Figure 3 provides a graphical comparison between each of these conditions.

Table 1. Means for overall workload.

Workload	Mean	Standard Error	95% Confidence Interval	
			Lower Boundary	**Upper Boundary**
Baseline	30.833	3.782	22.510	39.157
CAB	33.333	5.303	21.661	45.006
NoCAB	42.750	5.264	31.163	54.337

Table 2. MANOVA for overall workload.

Effect		Value	F	Hypothesis df	Error df	Sig.
WKLOAD	Wilks' lambda (λ)	.465	5.181	2.000	9.000	**.032***
WKLOAD x ORDER	Wilks' lambda (λ)	.670	2.220	2.000	9.000	.165

*Statistically significant effect at $p \leq 0.05$.

Table 3. ANOVA for overall workload.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
WKLOAD	947.722	2	473.861	7.114	**.005***
WKLOAD x ORDER	400.722	2	200.361	3.008	.072
Error(WKLOAD)	1332.222	20	66.611		

*Statistically significant effect at $p \leq 0.05$ and also significant in MANOVA.

Table 4. Tukey-Kramer comparisons for overall workload-dependent variables.

(I) WKLOAD	(J) WKLOAD	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Boundary	Upper Boundary
Baseline	CAB	-2.500	2.957	.418	-9.088	4.088
	NoCAB	-11.917	3.643	**.008***	-20.034	-3.799
CAB	Baseline	2.500	2.957	.418	-4.088	9.088
	NoCAB	-9.417	3.360	**.019***	-16.903	-1.930
NoCAB	Baseline	11.917	3.643	**.008***	3.799	20.034
	CAB	9.417	3.360	**.019***	1.930	16.903

*Statistically significant effect at $p \leq 0.05$.

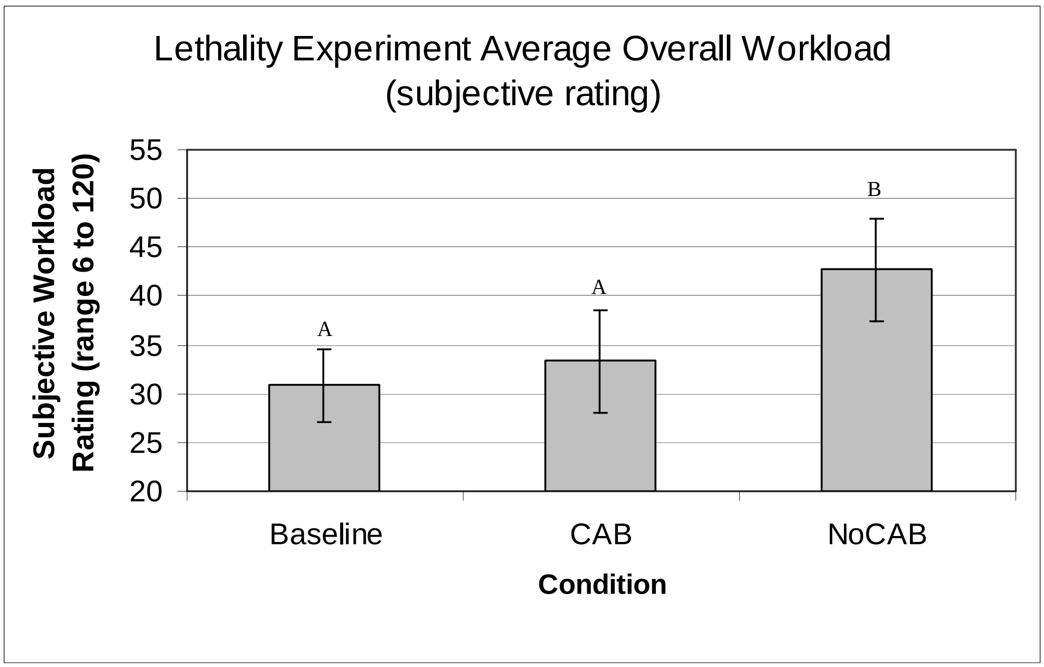

Figure 3. Comparison of overall workload across conditions. (Means with different letters are significantly different at $p \leq 0.05$.)

3.2 Workload Subscales

As previously stated, the NASA-TLX Workload Rating Scale provides for an overall workload score as well as a set of specific subscales of workload. Following are the results from these subscales. Presentation order was a between-subject factor and was analyzed to determine whether the order of condition (i.e., CAB first or NoCAB first) significantly affected workload.

The dependent variables included in the Workload Subscales model were Mental, Physical, Temporal, Performance, Effort, and Frustration, in each of three conditions: Baseline, CAB, and NoCAB. Means for this data set are shown in table 5. Significance (at $p \leq 0.05$) was observed

for Workload Subscales in the overall MANOVA model with the use of the Wilk's λ test (see table 6). No significant effect was observed in the MANOVA for Order or Order by Condition.

ANOVA results showed a significant effect for the Mental ($F_{2,20} = 8.321$, $p = 0.002$), Physical ($F_{2,20} = 3.503$, $p = 0.050$), Temporal ($F_{2,20} = 7.467$, $p = 0.004$), Performance ($F_{2,20} = 3.531$, $p = 0.049$), Effort ($F_{2,20} = 4.907$, $p = 0.018$), and Frustration ($F_{2,20} = 3.854$, $p = 0.038$) Workload Subscales. The ANOVA summary table for Workload Subscales is provided in table 7. Further analysis via Tukey-Kramer reveals that only the Mental, Temporal, and Effort subscales exhibited significant differences when compared across conditions (see table 8).

Table 5. Means for workload subscales.

Workload Subscale	**Order**	**Mean**	**Std. Error**	**95% Confidence Interval for Difference**	
				Lower Boundary	**Upper Boundary**
MENTAL	CAB First	4.500	1.306	1.590	7.410
	NoCAB First	7.500	1.306	4.590	10.410
PHYSICAL	CAB First	2.556	1.363	-.481	5.592
	NoCAB First	5.500	1.363	2.464	8.536
TEMPORAL	CAB First	3.167	1.204	.485	5.849
	NoCAB First	6.944	1.204	4.263	9.626
PERFORMANCE	CAB First	6.556	1.526	3.154	9.957
	NoCAB First	3.056	1.526	-.346	6.457
EFFORT	CAB First	4.611	2.051	.041	9.181
	NoCAB First	11.278	2.051	6.708	15.848
FRUSTRATION	CAB First	2.556	.850	.662	4.450
	NoCAB First	3.722	.850	1.828	5.616

Table 6. MANOVA for workload subscales.

Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**
WKLOAD SUBSCALE	Pillai's trace	1.157	3.661	12.000	32.000	.002
	Wilks' λ	.159	3.767	12.000	30.000	**.002***
	Hotelling's trace	3.296	3.846	12.000	28.000	.002
	Roy's largest root	2.502	6.673	6.000	16.000	.001
ORDER	Pillai's trace	.619	1.356	6.000	5.000	.378
	Wilks' λ	.381	1.356	6.000	5.000	.378
	Hotelling's trace	1.627	1.356	6.000	5.000	.378
	Roy's largest root	1.627	1.356	6.000	5.000	.378
WKLOAD SUBSCALE x ORDER	Pillai's trace	.601	1.146	12.000	32.000	.361
	Wilks' λ	.478	1.118	12.000	30.000	.383
	Hotelling's trace	.929	1.084	12.000	28.000	.409
	Roy's largest root	.691	1.842	6.000	16.000	.154

*Statistically significant effect at $p \leq 0.05$.

Table 7. ANOVA for workload subscales.

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
WKLOAD	MENTAL	181.500	2	90.750	8.351	**.002***
	PHYSICAL	31.722	2	15.861	3.503	**.050***
	TEMPORAL	62.889	2	31.444	7.467	**.004***
	PERFORMANCE	44.056	2	22.028	3.531	**.049***
	EFFORT	35.056	2	17.528	4.907	**.018***
	FRUSTRATION	48.222	2	24.111	3.854	**.038***
WKLOAD SUBSCALE x ORDER	MENTAL	11.167	2	5.583	.514	.606
	PHYSICAL	14.389	2	7.194	1.589	.229
	TEMPORAL	21.556	2	10.778	2.559	.102
	PERFORMANCE	45.167	2	22.583	3.620	.056
	EFFORT	.167	2	.083	.023	.977
	FRUSTRATION	16.667	2	8.333	1.332	.286
Error (WKLOAD SUBSCALE)	MENTAL	217.333	20	10.867		
	PHYSICAL	90.556	20	4.528		
	TEMPORAL	84.222	20	4.211		
	PERFORMANCE	124.778	20	6.239		
	EFFORT	71.444	20	3.572		
	FRUSTRATION	125.111	20	6.256		

*Statistically significant effect at $p \leq 0.05$ and also significant in MANOVA

Table 8. Tukey-Kramer comparisons for workload subscales.

WKLOAD SUBSCALE	(I) COND	(J) COND	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower Boundary	Upper Boundary
MENTAL	Baseline	CAB	-2.750	1.539	.104	-6.179	.679
		NoCAB	-5.500	1.662	**.008***	-9.204	-1.796
	CAB	Baseline	2.750	1.539	.104	-.679	6.179
		NoCAB	-2.750	.549	**.001***	-3.973	-1.527
	NoCAB	Baseline	5.500	1.662	**.008***	1.796	9.204
		CAB	2.750	.549	**.001***	1.527	3.973
PHYSICAL	Baseline	CAB	.417	.523	.444	-.749	1.582
		NoCAB	-1.750	.797	.053	-3.525	.025
	CAB	Baseline	-.417	.523	.444	-1.582	.749
		NoCAB	-2.167	1.164	.092	-4.761	.428
	NoCAB	Baseline	1.750	.797	.053	-.025	3.525
		CAB	2.167	1.164	.092	-.428	4.761
TEMPORAL	Baseline	CAB	-1.000	.745	.209	-2.661	.661
		NoCAB	-3.167	1.078	**.015***	-5.568	-.766
	CAB	Baseline	1.000	.745	.209	-.661	2.661
		NoCAB	-2.167	.624	**.006***	-3.556	-.777
	NoCAB	Baseline	3.167	1.078	**.015***	.766	5.568
		CAB	2.167	.624	**.006***	.777	3.556
PERFORMANCE	Baseline	CAB	2.583	1.200	.057	-.091	5.257
		NoCAB	2.000	1.098	.099	-.446	4.446
	CAB	Baseline	-2.583	1.200	.057	-5.257	.091
		NoCAB	-.583	.688	.416	-2.117	.950
	NoCAB	Baseline	-2.000	1.098	.099	-4.446	.446
		CAB	.583	.688	.416	-.950	2.117

EFFORT	Baseline	CAB	1.167	.833	.192	-.690	3.023
		NoCAB	-1.250	.827	.162	-3.094	.594
	CAB	Baseline	-1.167	.833	.192	-3.023	.690
		NoCAB	-2.417	.638	**.004***	-3.838	-.995
	NoCAB	Baseline	1.250	.827	.162	-.594	3.094
		CAB	2.417	.638	**.004***	.995	3.838
FRUSTRATION	Baseline	CAB	-.500	.350	.183	-1.279	.279
		NoCAB	-2.667	1.256	.060	-5.465	.132
	CAB	Baseline	.500	.350	.183	-.279	1.279
		NoCAB	-2.167	1.195	.100	-4.829	.496
	NoCAB	Baseline	2.667	1.256	.060	-.132	5.465
		CAB	2.167	1.195	.100	-.496	4.829

*Statistically significant effect at $p \leq 0.05$.

3.2.1 Mental Workload

For Mental Workload, a significant difference was observed between Baseline and NoCAB and between CAB and NoCAB. For the Baseline and NoCAB comparison, results indicate that mental workload was significantly higher in the NoCAB condition (8.75) than in the Baseline condition (3.25). Similarly, results indicate that mental workload was significantly higher in the NoCAB condition (8.75) than in the CAB condition (6.0). There was no significant difference between the Baseline and CAB conditions for Mental Workload. Figure 4 provides a graphical comparison between each of these conditions for Mental Workload.

3.2.2 Temporal Workload

For Temporal Workload, a significant difference was observed between Baseline and NoCAB and between CAB and NoCAB. For the Baseline and NoCAB comparison, results indicate that temporal workload was significantly higher in the NoCAB condition (6.83) than in the Baseline condition (3.67). Results indicate that temporal workload was significantly higher in the NoCAB condition (6.83) than in the CAB condition (4.67). There was no significant difference between the Baseline and CAB conditions for Temporal Workload. Figure 5 provides a graphical comparison between each of these conditions for temporal workload.

3.2.3 Effort Workload

For Effort Workload, a significant difference was observed only between CAB and NoCAB. Results indicate that effort workload was significantly higher in the NoCAB condition (9.17) than in the CAB condition (6.75). Although effort workload was lower in the CAB condition than in the Baseline condition, this difference was not significant. Figure 6 provides a graphical comparison between each of these conditions for Effort Workload.

Figure 7 provides a graphical comparison between all Workload Subscales across the three conditions. Although only the Mental, Temporal, and Effort subscales are significant, this figure clearly shows the trend of increasing workload for all subscales in the NoCAB condition when compared with the Baseline and CAB conditions. Also, it can be seen that effort is reduced when CABs were used, compared with the Baseline and NoCAB conditions. Finally, this graph shows

that participants perceived that their performance was increased slightly when they used the CABs, compared to when they did not use the CABs (note that performance is a reverse scale).

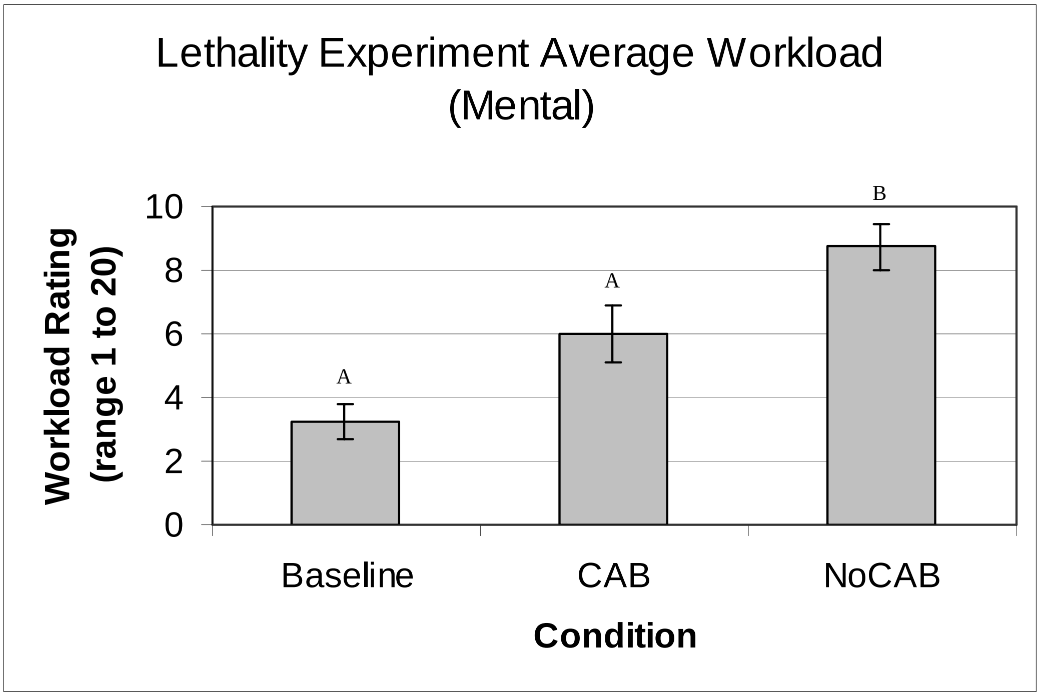

Figure 4. Comparison of mental workload across conditions. (Means with different letters are significantly different at $p \leq 0.05$.)

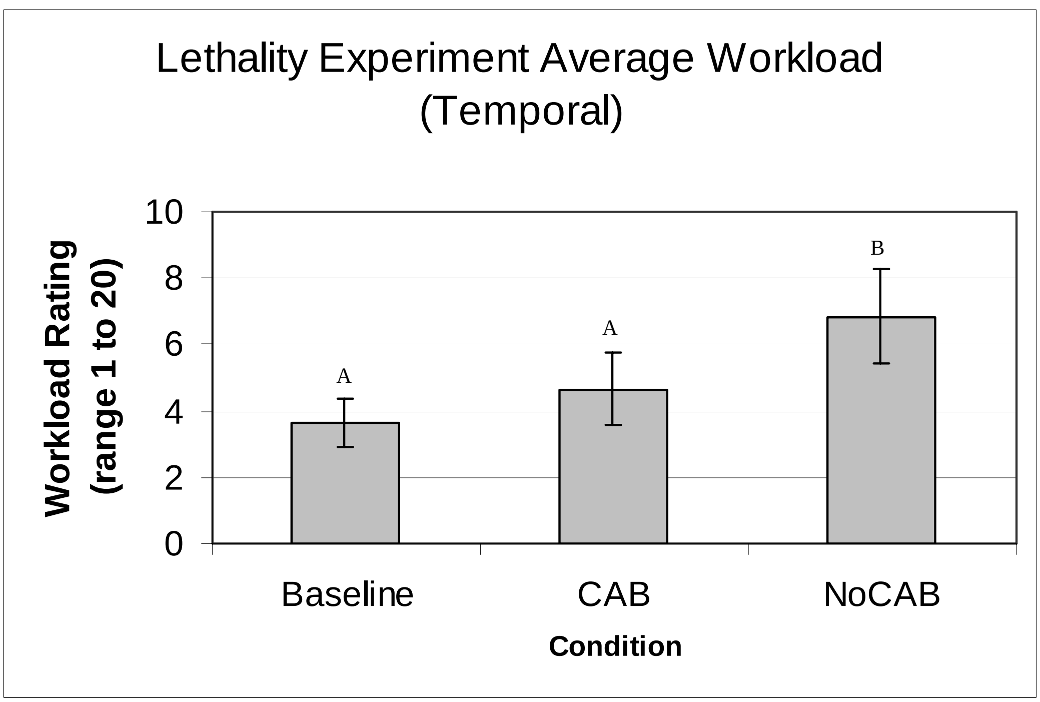

Figure 5. Comparison of temporal workload across conditions. (Means with different letters are significantly different at $p \leq 0.05$.)

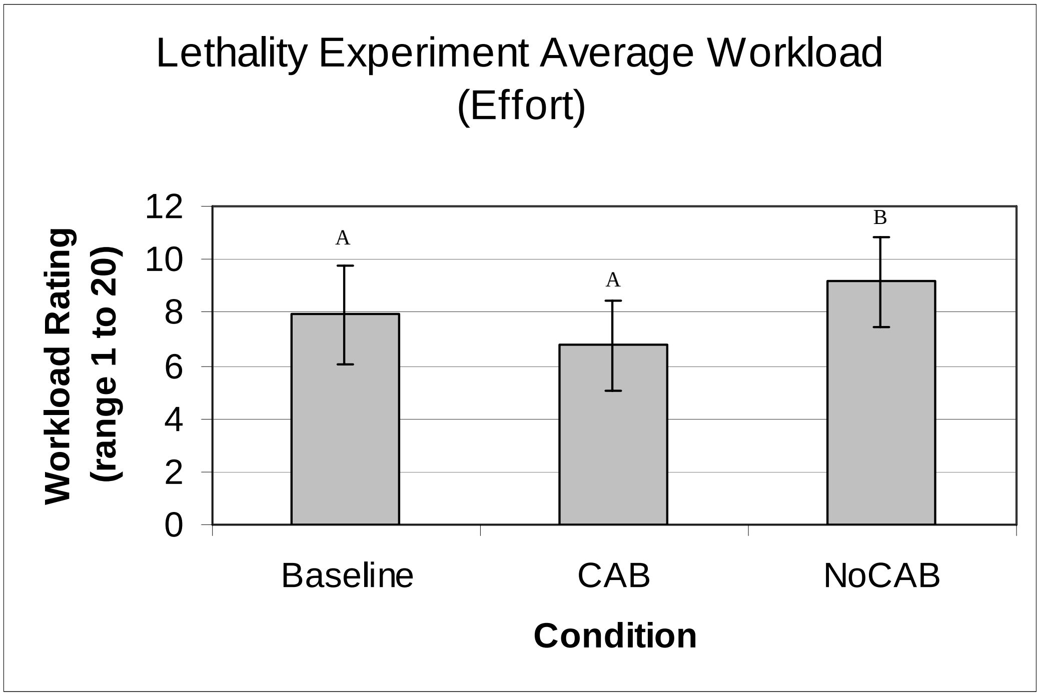

Figure 6. Comparison of temporal workload across conditions. (Means with different letters are significantly different at $p \leq 0.05$.)

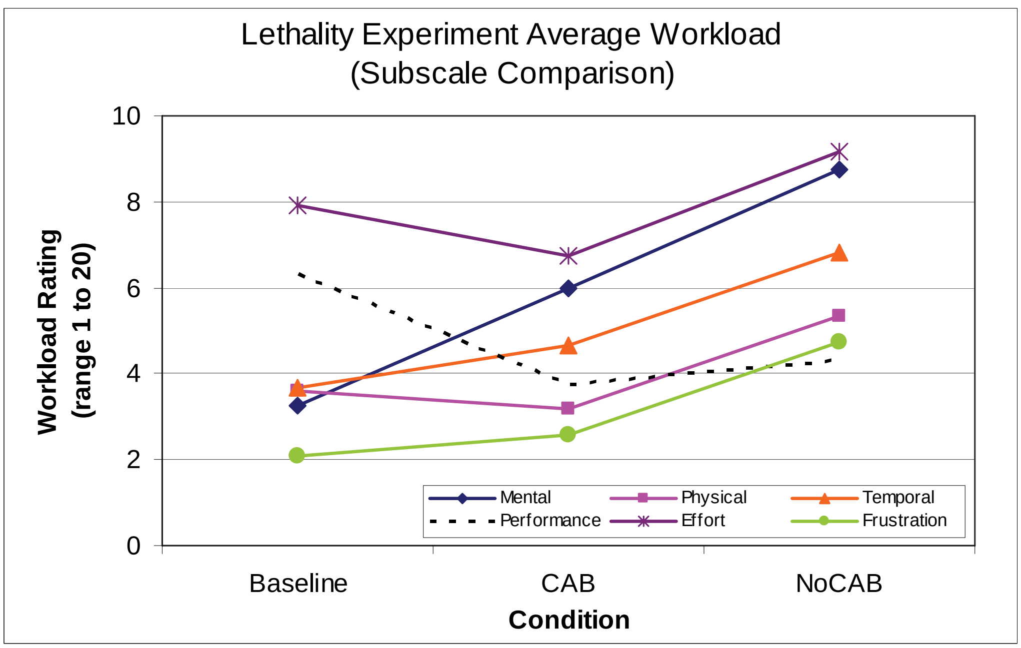

Figure 7. Workload subscale comparison across conditions (performance is a reverse scale).

3.3 Stress

Mental stress and physical stress data were evaluated across conditions. Comparisons between mental and physical stress within each condition were not conducted since differences between

the two were expected but not relevant to this effort. Presentation order was a between-subject factor and was analyzed to determine whether the order of condition (i.e., CAB first or NoCAB first) significantly affected stress.

For the dependent variable Mental Stress, the three levels in the overall model were Baseline Mental Stress, CAB Mental Stress, and NoCAB Mental Stress. Means for this data set are shown in table 9. No statistical significance (at $p \leq 0.05$) was observed for Mental Stress in the overall MANOVA model using the Wilk's λ test (see table 10). Inspection of the ANOVA for Mental Stress also showed no significance.

For the dependent variable Physical Stress, the three levels in the overall model were Baseline Physical Stress, CAB Physical Stress, and NoCAB Physical Stress. Means for this data set are shown in table 11. Significance (at $p \leq 0.05$) was observed for Physical Stress in the overall MANOVA model using the Wilk's λ test (see table 12). No significant effect was observed in the MANOVA for Order or Order by Condition.

Although MANOVA results for Physical Stress showed significance in the overall model, a closer inspection of the data via the ANOVA showed no significant effect for Physical Stress ($F_{2,22} = 3.462$, $p = 0.051$), albeit just slightly non-significant. The ANOVA summary table for Physical Stress is provided in table 13. Although statistical significance was not observed across conditions for physical or mental stress, figure 8 is provided to show the general trend of increasing stress (both physical and mental) in the NoCAB condition when compared with the Baseline and CAB conditions. It is also shown that stress (both physical and mental) is only slightly elevated in the CAB condition when compared to the Baseline condition.

Table 9. Means for mental stress.

MSTRESS	Mean	Standard Error	95% Confidence Interval	
			Lower Boundary	Upper Boundary
Baseline	2.000	.246	1.458	2.542
CAB	2.083	.288	1.450	2.716
NoCAB	2.667	.333	1.933	3.400

Table 10. MANOVA for mental stress.

Effect		Value	F	Hypothesis df	Error df	Sig.
MSTRESS	Pillai's trace	.359	2.516	2.000	9.000	.136
	Wilks' λ	.641	2.516	2.000	9.000	.136
	Hotelling's trace	.559	2.516	2.000	9.000	.136
	Roy's largest root	.559	2.516	2.000	9.000	.136
MSTRESS x ORDER	Pillai's trace	.229	1.339	2.000	9.000	.310
	Wilks' λ	.771	1.339	2.000	9.000	.310
	Hotelling's trace	.298	1.339	2.000	9.000	.310
	Roy's largest root	.298	1.339(a)	2.000	9.000	.310

*Statistically significant effect at $p \leq 0.05$.

Table 11. Means for physical stress.

PSTRESS	Mean	Standard Error	95% Confidence Interval	
			Lower Boundary	Upper Boundary
Baseline	1.667	.284	1.041	2.292
CAB	1.667	.225	1.172	2.161
NoCAB	2.167	.322	1.458	2.875

Table 12. MANOVA for physical stress.

Effect		Value	F	Hypothesis df	Error df	Sig.
PSTRESS	Pillai's trace	.529	5.063	2.000	9.000	.034
	Wilks' λ	.471	5.063	2.000	9.000	**.034***
	Hotelling's trace	1.125	5.063	2.000	9.000	.034
	Roy's largest root	1.125	5.063	2.000	9.000	.034
PSTRESS x ORDER	Pillai's trace	.111	.563	2.000	9.000	.589
	Wilks' λ	.889	.563	2.000	9.000	.589
	Hotelling's trace	.125	.563	2.000	9.000	.589
	Roy's largest root	.125	.563	2.000	9.000	.589

*Statistically significant effect at $p \leq 0.05$.

Table 13. ANOVA for physical stress.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
PSTRESS	2.000	2	1.000	3.462	.051
PSTRESS x ORDER	.222	2	.111	.385	.686
Error(PSTRESS)	5.778	20	.289		

*Statistically significant effect at $p \leq 0.05$ and also significant in MANOVA.

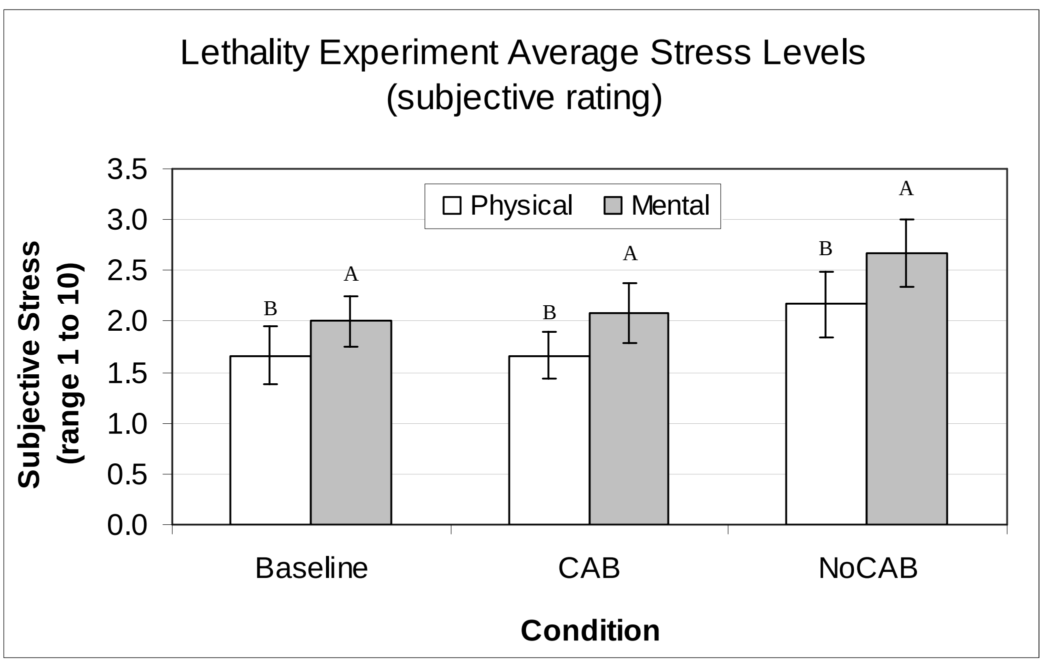

Figure 8. Comparison of physical and mental stress across conditions. (Means with different letters are significantly different at $p \leq 0.05$.)

3.4 Situation Awareness

The dependent variable included in the overall model was SA. The three levels of SA were Baseline SA, CAB SA, and NoCAB SA. Presentation order was a between-subject factor and was analyzed to determine whether the order of condition (i.e., CAB first or NoCAB first) significantly affected SA. Means for this data set are shown in table 14. No statistical significance (at $p \leq 0.05$) was observed for SA in the overall MANOVA model using the Wilk's λ test (see table 15). No significant effect was observed in the MANOVA for Order or Order by Condition.

Although statistical significance was not observed across conditions for SA, figure 9 is provided to show the trend of decreasing SA in the NoCAB condition when compared with the Baseline and CAB conditions and to show that SA is slightly increased in the CAB condition when compared to the Baseline condition.

Table 14. Means for situation awareness.

SITUATION AWARENESS	**Mean**	**Standard Error**	**95% Confidence Interval**	
			Lower Boundary	**Upper Boundary**
Baseline	9.000	.337	8.248	9.752
CAB	9.167	.284	8.534	9.799
NoCAB	8.583	.271	7.979	9.188

Table 15. MANOVA for situation awareness.

Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**
SITUATION AWARENESS	Pillai's trace	.459	3.813	2.000	9.000	.063
	Wilks' λ	.541	3.813	2.000	9.000	.063
	Hotelling's trace	.847	3.813	2.000	9.000	.063
	Roy's largest root	.847	3.813	2.000	9.000	.063
SITUATION AWARE-NESS x ORDER	Pillai's trace	.301	1.940	2.000	9.000	.199
	Wilks' λ	.699	1.940	2.000	9.000	.199
	Hotelling's trace	.431	1.940	2.000	9.000	.199
	Roy's largest root	.431	1.940	2.000	9.000	.199

*Statistically significant effect at $p \leq 0.05$.

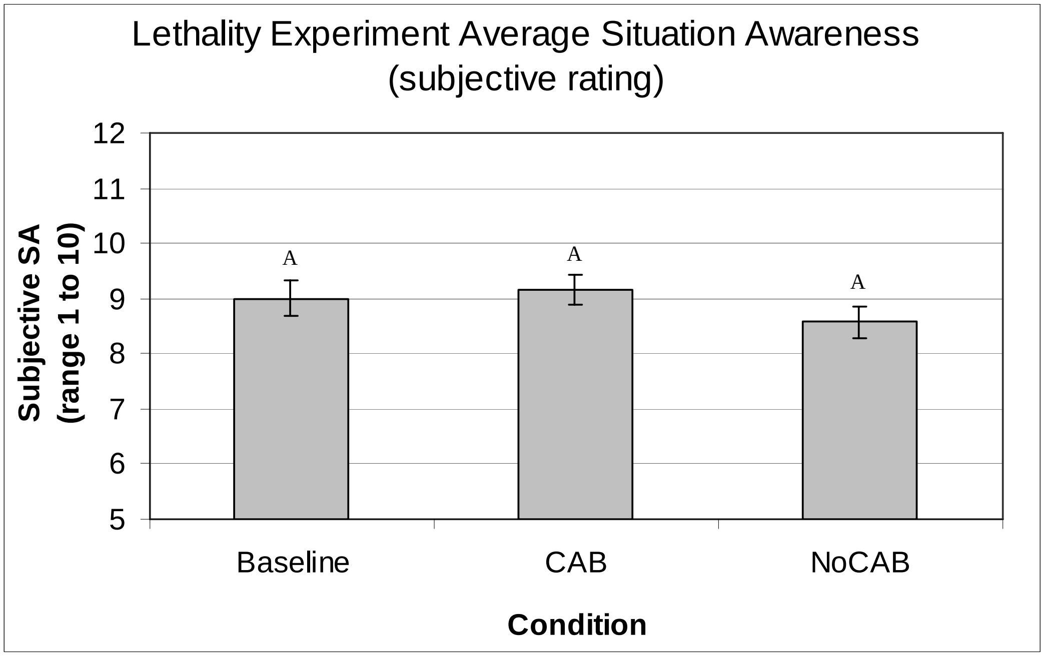

Figure 9. Comparison of situation awareness across conditions. (Means with different letters are significantly different at $p \leq 0.05$.)

3.5 Task Time

The dependent variable included in the overall model was Task Time. The two levels of Task Time were CAB Task Time and NoCAB Task Time. Presentation order was a between-subject factor and was analyzed to determine whether the order of condition (i.e., CAB first or NoCAB first) significantly affected task time. Means for this data set are shown in table 16. Significance (at $p \leq 0.05$) was observed for Task Time and the interaction of Task Time and Presentation Order in the overall MANOVA model with the Wilk's λ test (see table 17).

ANOVA results also showed a significant effect for Task Time ($F_{1,10} = 66.076$, $p < 0.0001$) and the interaction of Task Time and Presentation Order ($F_{2,22} = 7.707$, $p = 0.020$). The ANOVA summary table for Task Time is provided in table 18. *Post hoc* results were not conducted since there were only two levels of the independent variable. To determine the loci of significance between the two levels of task time (shown to be significant) and between the two levels of presentation order (also shown to be significant), the means were examined. Interaction means are shown in table 19.

Figure 10 shows the average time to complete the task in both conditions. As stated, results showed a significant difference between conditions for time to complete the task. Participants took significantly less time to complete the task in the CAB condition (5.32 minutes) than in the NoCAB condition (8.26 minutes).

Figure 11 shows the significant interaction effect between condition and presentation order. Results from the interaction means table (table 19) and figure 11 indicate that in the NoCAB condition, when NoCAB was presented first, participants took significantly longer time to

complete the task (9.13 minutes) than those participants who were presented CAB first (7.38). Conversely, time to complete the task in the CAB condition was not significantly different, regardless which condition was presented first (i.e., 5.45 minutes with CAB first versus 5.18 minutes with NoCAB first).

3.5.1 Engagement-only Analysis

To assess the potential effect or bias on the engagement-only subtask, a secondary analysis was conducted only on the targets engaged by the Soldiers. This data set did not include the prioritization or weapon and munition selection subtasks and included only those targets engaged by all Soldiers. That is, some Soldiers did not engage some targets because ammunition was depleted before all targets could be engaged (caused by multiple shots on the same targets because of system fidelity problems). When these targets (a total of three) were removed from the data set and the remaining data were analyzed, it was shown that engagement-only times, that is, without the task of prioritizing targets, were not significantly different across conditions (see figure 12). This was expected since target engagement should not have been affected by condition.

Results from this secondary analysis are only reported here to further illustrate the effect of the CABs in the prioritization analysis because this test eliminates the potential effect of engagement time from the prioritization time. That is, the task of selecting and shooting targets should have been (and was) the same in each condition and should not have been influenced (and was not) by the CABs or absence of CABs. That is, it can be stated that the significant differences between conditions in the prioritization portion of the task are unambiguous in that the observed differences were caused by the factors of interest and were in no way biased by an engagement effect.

Table 16. Means for task time.

TASK TIME	Mean	Standard Error	95% Confidence Interval	
			Lower Boundary	Upper Boundary
CAB	318.917	9.774	297.138	340.696
NoCAB	495.333	19.972	450.834	539.833

Table 17. MANOVA for task time.

Effect		Value	F	Hypothesis df	Error df	Sig.
TASK TIME	Pillai's trace	.869	66.076	1.000	10.000	.000
	Wilks' λ	.131	66.076	1.000	10.000	**.000***
	Hotelling's trace	6.608	66.076	1.000	10.000	.000
	Roy's largest root	6.608	66.076	1.000	10.000	.000
TASK TIME x ORDER	Pillai's trace	.435	7.707	1.000	10.000	.020
	Wilks' λ	.565	7.707	1.000	10.000	**.020***
	Hotelling's trace	.771	7.707	1.000	10.000	.020
	Roy's largest root	.771	7.707	1.000	10.000	.020

*Statistically significant effect at $p \leq 0.05$.

Table 18. ANOVA for task time.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
TASKTIME	373474.083	1	373474.083	66.076	**.000***
TASKTIME x ORDER	43560.750	1	43560.750	7.707	**.020***
Error(TASKTIME)	56522.167	10	5652.217		

*Statistically significant effect at $p \leq 0.05$ and also significant in MANOVA.

Table 19. Means for task time and presentation order.

ORDER	TASK TIME	Mean	Standard Error	95% Confidence Interval	
				Lower Boundary	**Upper Boundary**
CAB First	CAB	326.833	13.823	296.033	357.633
	NoCAB	443.000	28.244	380.068	505.932
NoCAB First	CAB	311.000	13.823	280.200	341.800
	NoCAB	547.667	28.244	484.735	610.598

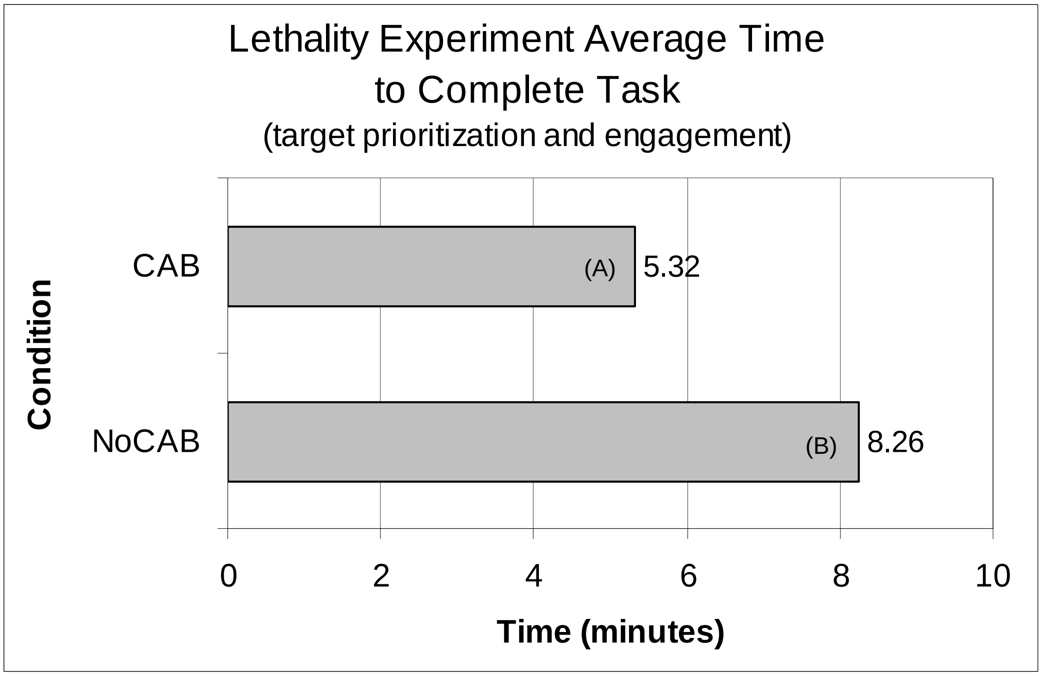

Figure 10. Average time to complete task. (Means with different letters are significantly different at $p \leq 0.05$.)

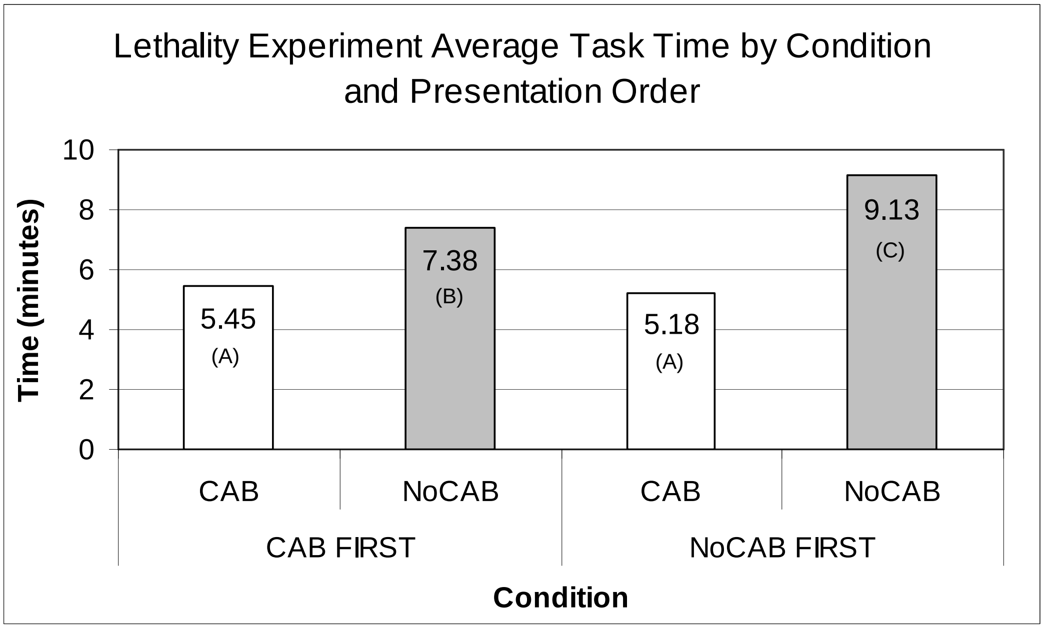

Figure 11. Condition x Presentation Order interaction. (Means with different letters are significantly different at $p \leq 0.05$.)

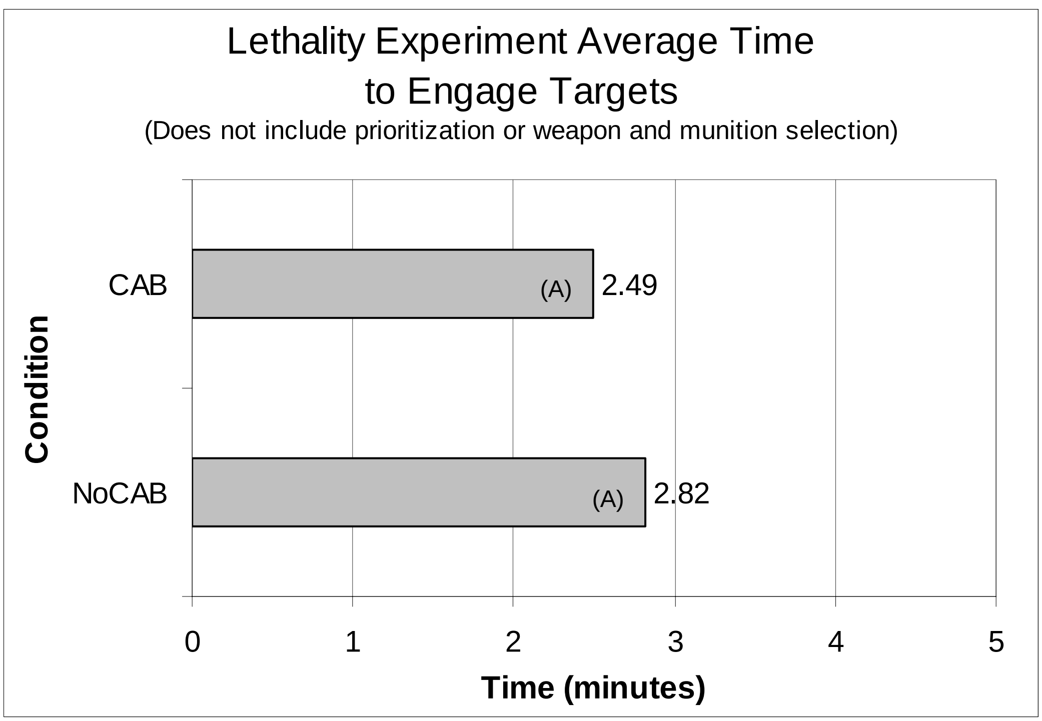

Figure 12. Average engagement-only times. (Means with different letters are significantly different at $p \leq 0.05$.)

4. Discussion

4.1 Workload

Results of this study show that CABs that aid the Soldier in prioritizing targets and selecting the appropriate weapons platform and munition type have a significant impact on overall Soldier workload. Specifically, overall workload was significantly reduced when Soldiers conducted target prioritization and engagement tasks using CABs. Conversely, overall workload was significantly increased, compared with baseline and CAB conditions, when Soldiers conducted the same tasks without using CABs. The CABs provided the Soldiers with a pre-sorted list of known targets, their threat potential, and their proximity. This information was then automatically matched with an appropriate weapons platform and munition type that was recommended to the Soldier for use in target engagement. In the absence of these decision aids, Soldiers scrolled through and visually scanned the list of known targets, assessed each for threat, proximity, and appropriate weapon and munition type for engagement, and then kept track of this information mentally while they conducted a mental sort, prioritization, and recommendation procedure.

As stated, the workload subscale results showed a significant difference between CAB and NoCAB for mental, temporal, and effort workload. For mental workload, significant difference between conditions means that without CABs, a significantly greater mental demand was placed on the Soldier during the task. That is, Soldiers were required to look, search, think, calculate and remember significantly more than when they used the CABs to complete the same task. Using CABs allowed the Soldiers to perform their task while significantly reducing their mental workload. Similarly, CABs significantly reduced Soldier's temporal workload, when compared with the NoCAB condition. This means that Soldiers did not feel significant time pressure while performing their task when using CABs. However, when they did not use CABs, Soldiers felt significant time pressure to complete their task. This pressure contributed to the overall workload experienced when Soldiers did not use CABs. CABs significantly reduced the Soldiers' effort workload when compared with the NoCAB condition. This means that using CABs to perform their task significantly reduced the effort required to prioritize and engage known targets. Without CABs, Soldiers felt they needed to work significantly harder (i.e., exert greater effort) to prioritize and engage the targets.

Although only the mental, temporal, and effort workload subscales were significant, all workload subscales showed the general trend of increasing workload for all subscales in the NoCAB condition when compared with the Baseline and CAB conditions. It is believed that a larger study with a larger sample size would show that this trend continues to increase and would show a significant effect across all workload subscales. Results also showed that participants perceived their performance was increased slightly when they used the CABs, compared to when they did not

use the CABs. Again, with a larger sample size, it is believed this trend would also become statistically significant.

4.2 Stress

As the results indicated, physical stress was only slightly non-significant. Even though no significance was observed, the general trend of increasing stress (both mental and physical) may be seen between CAB and NoCAB. That is, both mental and physical stress are higher in the NoCAB condition than in the CAB or Baseline conditions. Although this is not statistically significant, it is believed this difference would become so with a larger sample size.

4.3 Task Time

Results showed a significant reduction in the amount of time required to complete the task when CABs were used versus when they were not. Specifically, Soldiers performed the task 36% faster when using CABs. This result is primarily because sorting, prioritizing, and weapon and munition assignment are conducted automatically in the CAB condition. In this condition, Soldiers merely needed to review the selection and recommendation before engagement. Without CABs, however, Soldiers were required to scroll through the list of known targets, assess each for threat, proximity, and appropriate weapon and munition type, and then keep track of this information mentally while they conducted a mental sort, prioritization, and recommendation procedure. This NoCAB condition took significantly greater time (8.26 minutes without CABs versus 5.32 minutes with CABs).

The significant Condition x Order interaction suggests the presence of a learning effect. That is, Soldiers in the NoCAB condition took less time to prioritize targets when the CAB condition was run first, versus second. This suggests that Soldiers "learned" from the way the CAB prioritized targets and used that knowledge to make their own prioritization faster in the NoCAB condition. There was no learning effect in the CAB conditions. Although learning effect is an unintended artifact, which was controlled by the counterbalancing of treatment order, it works in favor of the hypothesis that CABs aid performance. That is, without this learning effect, times in the NoCAB condition where CABs were run first would have been even longer, thus increasing the already large difference between CAB and NoCAB task times. In other words, without the learning effect, the positive effect of CABs, which is already significantly greater than NoCABs, would be even greater.

5. Conclusion

Results of this study have shown that CABs significantly reduce time and workload when Soldiers are conducting the task of prioritizing and engaging targets. Soldiers took significantly less time to complete the prioritization and engagement task when using CABs versus when they performed the same task manually (i.e., the NoCAB condition). Overall task time was reduced by 36% when CABs were used.

Overall workload, as well as the subscales of mental, temporal, and effort workload, were significantly reduced when CABs were used. Overall workload was 28% less when CABs were used versus when they were not. Mental and temporal workload were both 46% less when CABs were used versus when they were not, and effort workload was 36% less when CABs were used versus when they were not.

For those performance measures that were not shown to be significant (i.e., situation awareness, stress, and the remaining workload subscales), results indicate that these measures exhibit the general trend of favoring the CAB condition versus the NoCAB condition. For example, both mental and physical stress, while only slightly non-significant, exhibit a generally decreasing trend in the CAB condition. Decreasing stress is a positive contribution. Similarly, again, while only slightly non-significant, situation awareness exhibits a generally decreasing trend in the NoCAB condition (it is only slightly increased in the CAB condition). Decreasing SA is not a positive contribution. Situation awareness was not decreased when CABs were used for this task.

It is apparent from the statistical results of this study that CABs provide beneficial effect for Soldiers when they are performing the task of target prioritization and engagement as outlined in this study. It is believed that the general trend observed in the non-significant results would become statistically significant if a larger sample size were exposed to the same conditions outlined in this study.

6. References

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Appendix A. SIL Crew Station Layout and Functionality Descriptions

(from AMRDEC training slides)

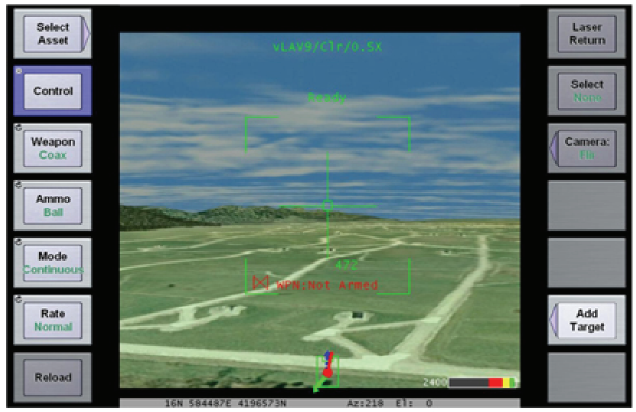
Target Acquisition Display – Yoke Controls

Magnification

- Increase / decrease the TA sensor magnification from 0.5X to 24X.

Slew

- Slew TA sensor left / right
- Tilt TA sensor up / down

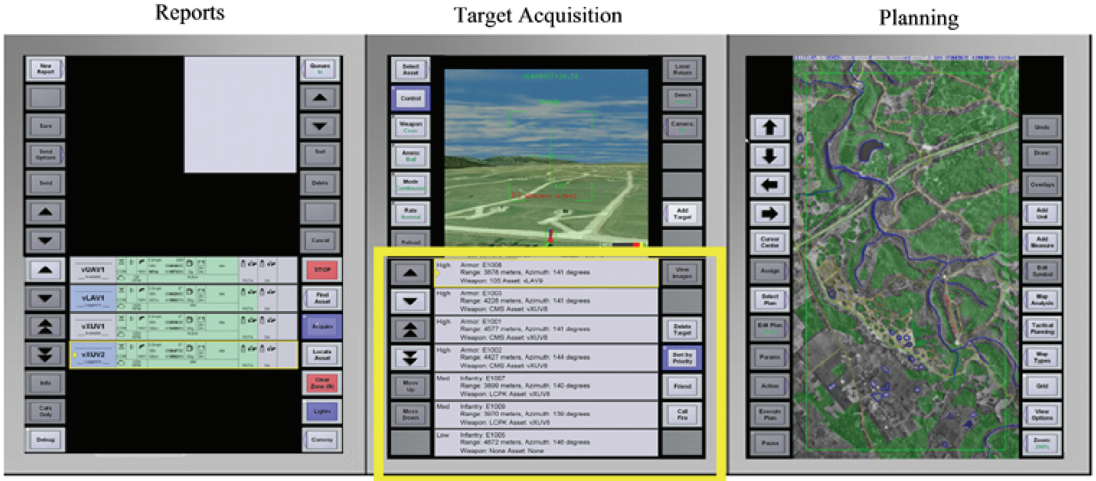


Fight Suite – Target Queue

Reports

Target Acquisition

Planning



Assets

Target Queue

Planning

Target Queue Display

1 **Sort Target List**

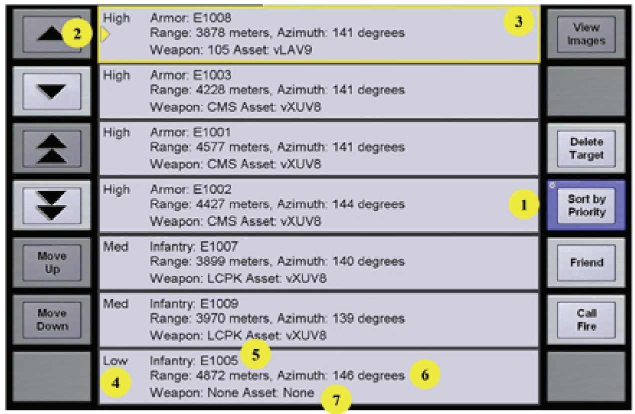
2 **Highlight Target**

- Scroll thru queue to highlight targets by using touch-screen or TGT LIST button on yoke

> Note: Highlighted Target will have cross-hairs overlaid on it on SA map

3 **Select Target**

- Select target by depressing TGT LIST button on yoke (will slew the TA sensor)



- **Target Details**
  - 4 Target Priority
  - 5 Target Type & ID
  - 6 Range from CAT (vLAV9) & Az position of Weapon System
  - 7 Weapon Recommendation & Asset

Scenario Specific Strategies

- **Mission**
  - You are a gunner operating as part of 3 man MCS crew. You have been Task Organized with an ARV-A and ARV-R. And, you are providing fire support for an RS&V Company. Your PLT LDR has detected a potential threat at approximately 2.5km from your vehicle that requires additional recon / surveillance. He has instructed the ARV-R to investigate.
  - Your mission begins once the ARV-R recon is complete. Your mission is to analyze all targets that are available to you via the Target Queue and engage and defeat as many of those threats as possible, as quickly as possible.
  - You will be conducting two experiment runs. The first run will not prioritize any of the targets, nor will it provide any weapon recommendations. This is the no CABs condition. The second run will prioritize targets and provide weapon recommendations. This will be the CABs condition. The overall improvements in crew performance with the CABs will be measured.
  - Targets that you will encounter include:
    - T-72's, which have a maximum effective range of 3.5km
    - BMP-2's, equipped with Missile Launchers, also have a maximum effective range of 3.5km

Experiment – Initial State

- Initialize OTB and SA Server; load the X4 scenario in OTB
- Initialize MC2 (ensure the DSS is NOT connected); load X4
- Initialize SMI (CABs ON / OFF)
  - load the X4 scenario
  - bring up the FIGHT suite
  - login into vXUV8
  - adjust zoom factor of SA map
- Once all targets have been spotted, connect MC2 with DSS
- Begin experiment

Target Engagement Sequence (no CABS)

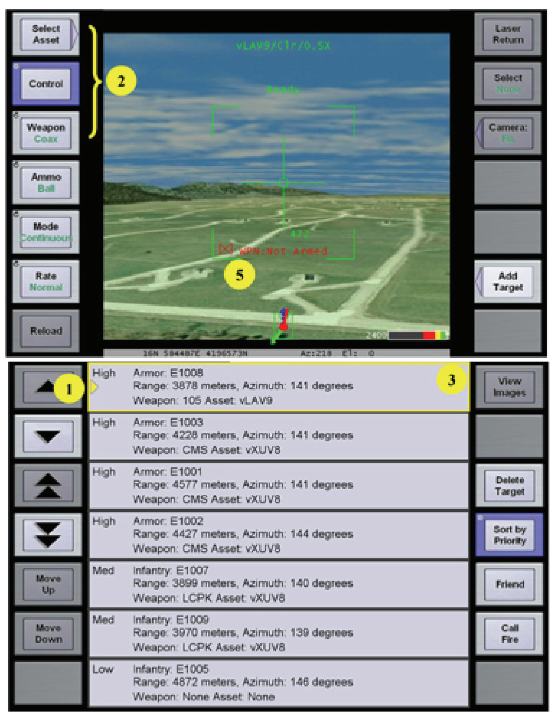
1. **Scroll thru target list; find target to engage; highlight target**
2. **Select Asset / Weapon**

NOTE: Operator may choose to override recommendation with selection

3. **Select Target & zoom sensor (if nec)**
4. **ARM Weapon System by depressing palm grips on yoke**

NOTE: This will AIM the Weapon System

5. **Wait for Fire Permit***
6. **Fire Weapon by pulling trigger**



Target Engagement Sequence (no CABS)

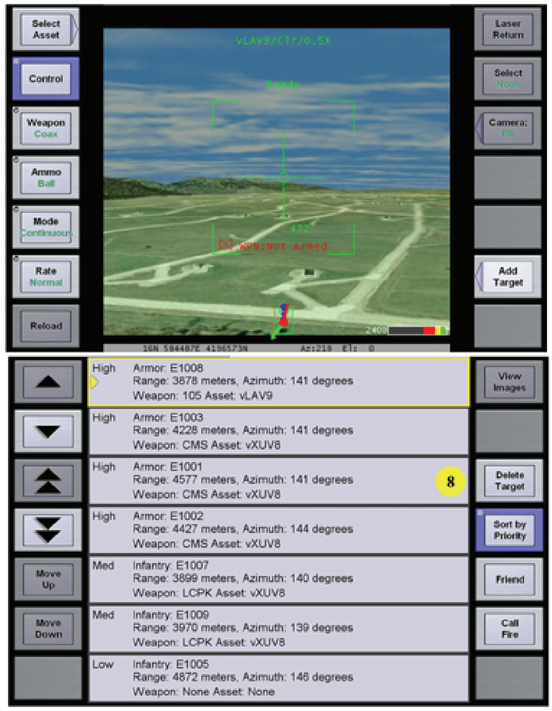
7 **Once munition has been fired, release Palm Grips**

8 **If target has been destroyed, delete target from Target Queue**

- For LOS targets, gunner will observe target destruction
- For BLOS targets, Observer will provide feedback to gunner

Note: When Target is removed from Target Queue, target is removed from SA screen

9 Service next target



Fire Permit – Common States

Not Armed
The gunner has not depressed the palm grips to arm the system. The system will not aim if it is not armed. Less frequently, this display indicates that no weapon is selected.

Out of Munitions
The current weapon is out of munitions. Less frequently, the system is not armed.

Out of Range
Only applicable to missile payloads. The target is either too close or too far away. The weapon will point in the direction of the target in anticipation of the target moving into range.

Designator Unavailable
The onboard designator can only fail to be available for two reasons: the target is beyond its range or the designator is currently illuminating a different target.

Fire Permit Granted

Target Engagement Sequence (CABS)

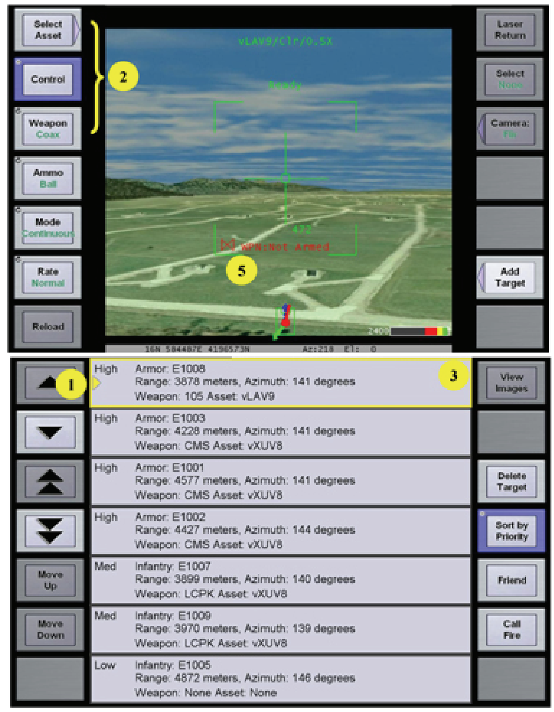
1. **Highlight first target in queue**
2. **Select Asset / Weapon**

NOTE: Operator may choose to override recommendation with selection

3. **Select Target & zoom sensor (if nec)**
4. **ARM Weapon System by depressing palm grips on yoke**

NOTE: This will AIM the Weapon System

5. **Wait for Fire Permit***
6. **Fire Weapon by pulling trigger**

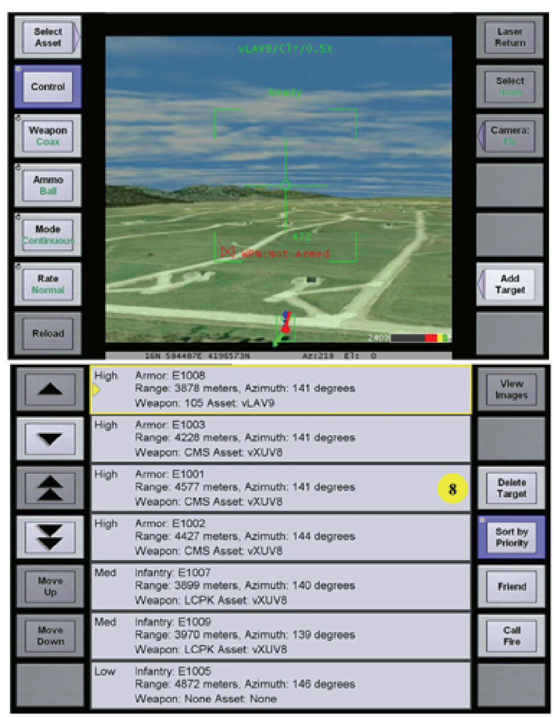


Target Engagement Sequence (CABS)

7. **Once munition has been fired, release Palm Grips**
8. **If target has been destroyed, delete target from Target Queue**
   - For LOS targets, gunner will observe target destruction
   - For BLOS targets, Observer will provide feedback to gunner

Note: When Target is removed from Target Queue, target is removed from SA screen

9. Service next target



The Basics

- CAT (vLAV9) and ARV-A (vXUV8) are equipped with weapon payloads and TA sensors
- ARV-R plays a recon support role and may acquire targets
- Higher echelon COP shared with CAT crew

- CAT (vLAV9)
  - TA sensor; range = 4km
  - 120mm cannon; 18 rounds
  - Coaxial Machine Gun; 2400 rounds / cont fire

- ARV-A (vXUV8)
  - TA sensor; range = 4km
  - LCPK; 19 rounds, min range 0.5km
  - CMS; 4 rounds, range 1km to 16km

The Basics

- **Mission**
  - You are a gunner operating as part of 3 man MCS crew. You have been Task Organized with an ARV-A and ARV-R. And, you are providing fire support for an RS&V Company. Your PLT LDR has detected a potential threat at approximately 2.5km from your vehicle that requires additional recon / surveillance. He has instructed the ARV-R to investigate.
  - Your mission begins once the ARV-R recon is complete. Your mission is to analyze all targets that are available to you via the Target Queue and engage and defeat as many of those threats as possible, as quickly as possible.
  - You will be conducting two experiment runs. The first run will not prioritize any of the targets, nor will it provide any weapon recommendations. This is the no CABs condition. The second run will prioritize targets and provide weapon recommendations. This will be the CABs condition. The overall improvements in crew performance with the CABs will be measured.

What Can You Accomplish with the Lethality Displays?

- **Acquire Targets**
  - Both CAT and ARV-A have TA sensors

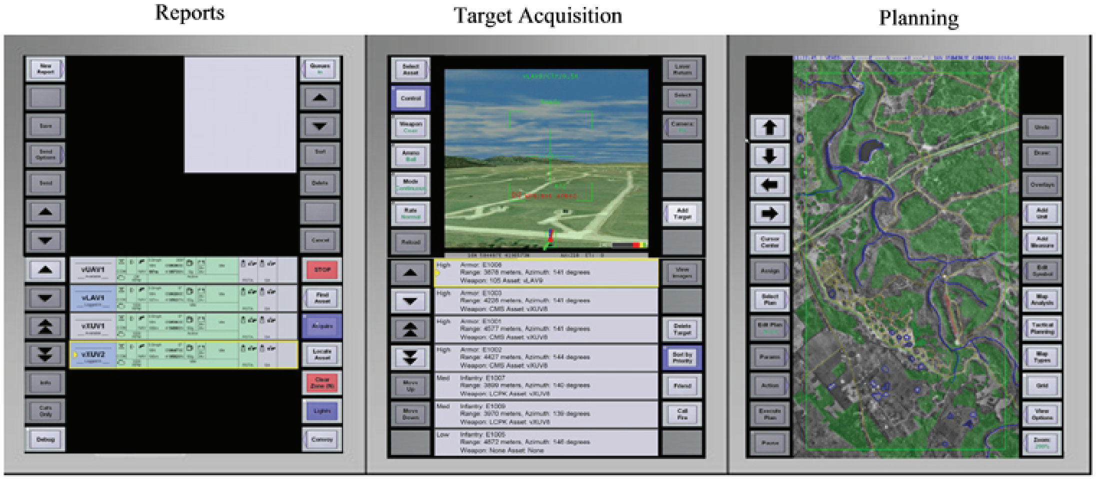
- **Engage Targets**
  - Both CAT and ARV-A have Direct Fire capability
  - ARV-A has Indirect Fire (BLOS) capability

When Would You Use Lethality Displays?

- Maintain local security / situational awareness
- When commanded to carry out Fire Mission Request

Fight Suite – Lethality Displays

Reports | Target Acquisition | Planning



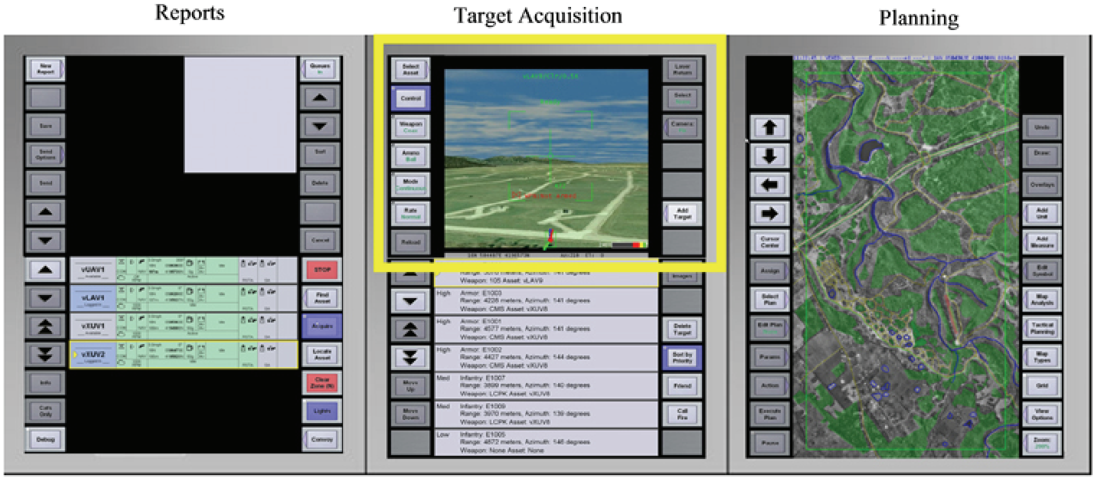
Assets | Target Queue | Planning

How do Lethality displays fit in with the Other Displays?

- **Target Acquisition**
  - Use to locate, acquire, and engage targets
- **Target Queue**
  - Sorted list provides target type, range, and firing recommendations
  - Select target in Target Queue to initiate firing sequence.
- **Planning / SA**
  - Provides SA that includes target location and proximity to friendlies
- **Reports**
  - RX Fire Mission Request from higher echelon
  - TX Call For Effects
- **Assets**
  - Provides list that includes assets under operator control

Fight Suite – Lethality Displays

Reports Target Acquisition Planning



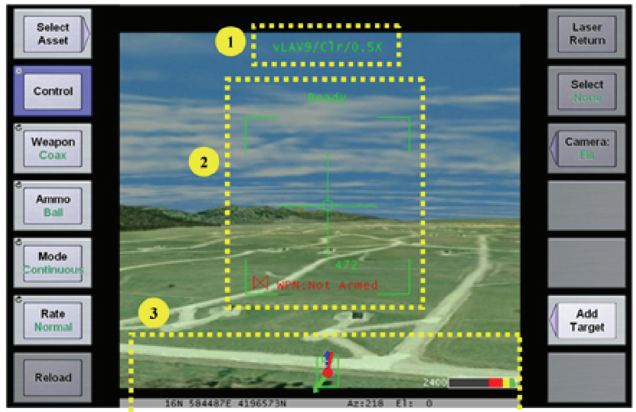
Assets Target Queue Planning

Target Acquisition Display

1. **TA Sensor Info**
   - Asset
   - Camera type
   - Zoom level

2. **Targeting Info**
   - Weapon System status
   - Crosshairs / Tracking gates
   - Fire Permit

3. **Vehicle Info**
   - Orientation Icon
   - Ammo count
   - Asset position
   - Weapon Az / El



Target Acquisition Display

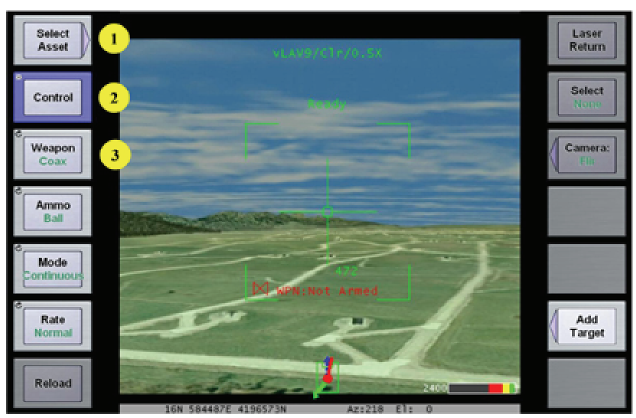
- **Both CAT** (vLAV9) **and ARV-A** (vXUV8) **have TA Sensors. To utilize a specific TA sensor, you must:**

1. **Select Asset**

2. **Take Control of Weapon System**
   (Weapon System state transitions from SAFE to READY)

   > NOTE: You must have acquired an Asset to be able to take control of the weapon system

3. **Select Weapon**



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Appendix B. Surveys

Participant ID:________________ Date:___________________ Armband:___________

Demographic Questionnaire

General:

1. DOB: _________ 2. Sex: M / F 3. Height: ________ft. _________in.

4. Weight: __________ lbs. 5. Handedness: Right / Left 6. Smoker: Y / N

7. Rank: ___________

8. Time in service: Yrs:______Mos:______

9. Time in grade: Yrs:______Mos:______

10. MOS/Specialty: ______________________

11. Time in MOS/Specialty: Yrs:______Mos:______

12. Combat experience: Y / N If Yes, Where? __________________ How long? ________

Experimentation:

9. How many UAMBL experiments (i.e., simulations in the battle lab) have you participated in? (if none, indicate 0): ______________

10. Indicate whether you have had experience, and at what level, for each the following:

a. Use of live CAT-Styrker vehicles

____None ____Basic ____Intermediate ____Advanced

b. Use of simulated CAT-Styrker vehicles

____None ____Basic ____Intermediate ____Advanced

c. Control of live unmanned systems (e.g., UAVs, UGVs, other)

____None ____Basic ____Intermediate ____Advanced

d. Control of simulated unmanned systems (e.g., UAVs, UGVs, other)

____None ____Basic ____Intermediate ____Advanced

e. Use of MC2 (Maneuver Command and Control)

____None ____Basic ____Intermediate ____Advanced

f. Use of FBCB2 (Force XXI Battle Command Brigade and Below)

____None ____Basic ____Intermediate ____Advanced

g. Use of COP (common operational picture interface) in CAT Stryker (live or simulated)

____None ____Basic ____Intermediate ____Advanced

h. Do you have any experience with computer games where you control a vehicle?

____None ____Basic ____Intermediate ____Advanced

NASA TLX Workload Assessment Instructions

We are interested in the "workload" you experienced during this scenario. Workload is something experienced individually by each person. One way to find out about workload is to ask people to describe what they experienced. Workload may be caused by many different factors and we would like you to evaluate them individually. The set of six workload rating factors was developed for you to use in evaluating your experiences during different tasks. Please read them. If you have a question about any of the scales in the table, please ask about it. It is extremely important that they be clear to you.

Definitions

Title	End points	Descriptions
MENTAL DEMAND	Low / High	How much mental and perceptual activity was required (that is, thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	Low / High	How much physical activity was required (that is, pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	Low / High	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	Poor / Good	How successful do you think you were in accomplishing the goals of the task? How satisfied were you with your performance in accomplishing these goals?
EFFORT	Low / High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL	Low / High	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

We want you to evaluate workload in two different ways. First, rate the workload on each factor on a scale. Each scale has two end descriptions, and 20 slots (hash marks) between the end descriptions. Place an "x" in the slot (between the hash marks) that you feel most accurately reflects your workload.

Next, we want you to compare the various workload factors. This comparison is a technique developed by NASA to evaluate the relative importance of the six workload sources you used to rate the workload you experienced. The procedure is simple: you have a sheet with a series of

pairs of workload sources (for example, Effort vs. Mental Demands). We want you to choose which of the sources was more important to your experience of the workload in the task that you performed. You will fill out a separate sheet for each task.

For each pair of sources, circle the source that is the more important contributor to the workload for the specific task you are rating. For example, for the first comparison, if effort contributes to workload more than performance, circle effort.

After you have finished the entire series, we will be able to use the pattern of your choices to create a weighted combination of ratings into a summary workload score.

We ask you to evaluate your workload for this scenario. This includes all the duties involved in your job (e.g., preparing your workstation, using displays and controls at your workstation).

Participant ID:_____ Date:________ Time:_________ Experiment:________
Condition:________

TLX Workload Scale

Please rate your workload by putting a mark on each of the six scales at the point which matches your experience.

Mental Demand

Very Low Very High

Physical Demand

Very Low Very High

Temporal Demand

Very Low Very High

Performance

Very Poor Very Good

Effort

Very Low Very High

Frustration

Very Low Very High

Participant ID:_____ Date:________ Time:_________ Experiment:________
Condition:________

Subjective Stress Rating Scale

1. The scale below represents a range of how PHYSICALLY stressful the mission might be. Check the block indicating how PHYSICALLY stressful the mission you just participated in was.

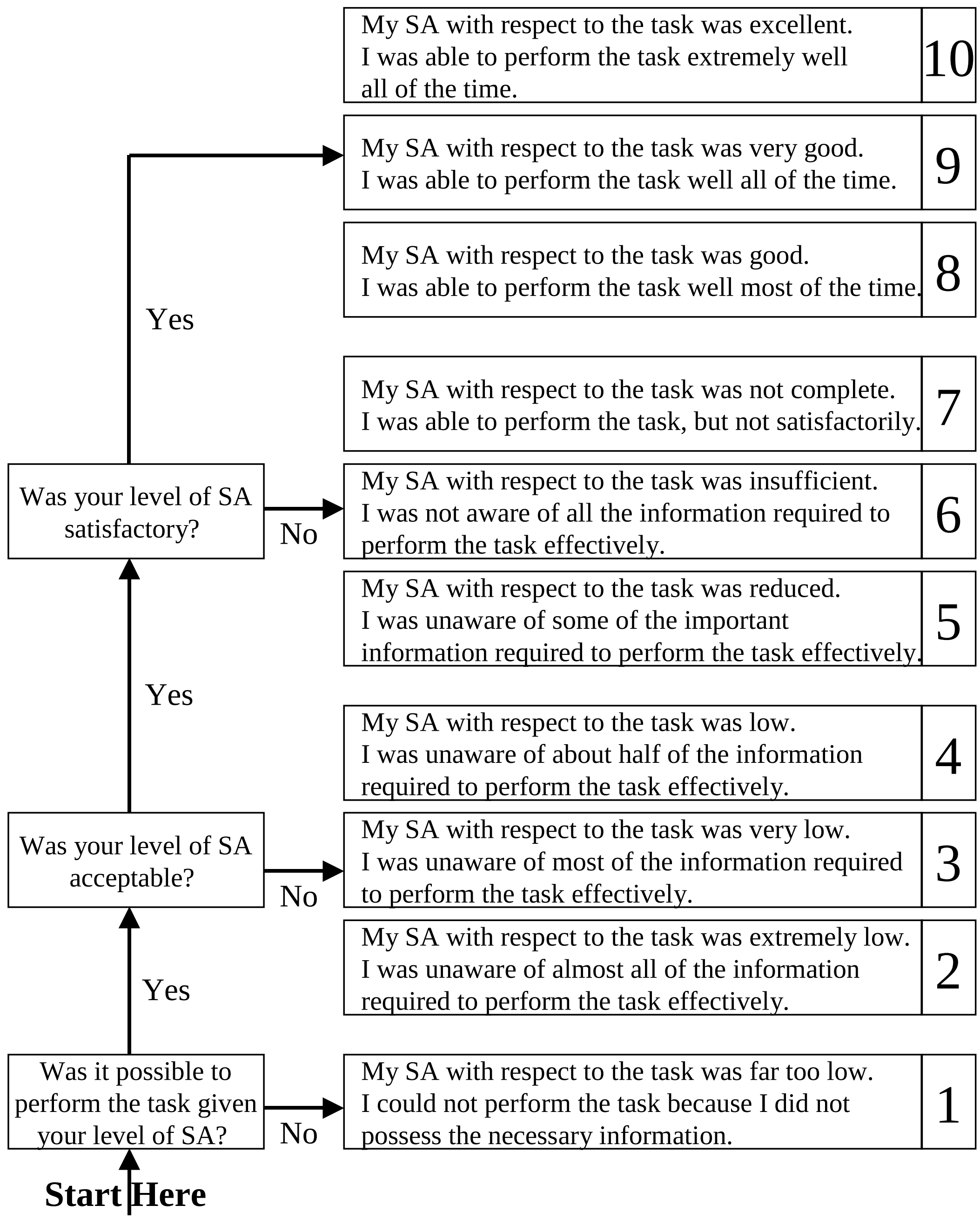
Task	Not at All Stressful 1	2	3	4	5	6	7	8	9	Most Possible Stress 10
a. Overall stress										

2. The scale below represents a range of how MENTALLY stressful the mission might be. Check the block indicating how MENTALLY stressful the mission that you just participated in was.

Task	Not at All Stressful 1	2	3	4	5	6	7	8	9	Most Possible Stress 10
a. Overall stress										

Participant ID:_____ Date:________ Time:_________ Experiment:________
Condition:________

Situation Awareness Rating Scale



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